Audio Programming 2

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On Today's Programme

Multichannel buffers

Multichannel buffers

Timing of sampling:

```
Frame(samples): [0]  [1]  [2]  [3]
Channel A:       A0   A1   A2   A3
Channel B:       B0   B1   B2   B3
Channel C:       C0   C1   C2   C3
```

- The time between frames is the sampling period
- In audio devices, sampling is often synchronous (that is: all the channels are sampled at exactly the same time)
- When multiple *frames* from multiple *channels* are stored in memory, they normally come in one of two formats: interleaved or non-interleaved

- Quiz:
  - With a sampling rate of 48kHz, if A0 was sampled at t = 0s, when was B3 sampled?
  - Answer: $t_3 = t_0 + 3 * 1/f_s$

Multichannel buffers

- An interleaved buffer containing 4 frames with 3 channels A, B, C, will look like:

float buffer[12] = { A0, B0, C0, A1, B1, C1, A2, B2, C2, A3, B3, C3};

- Weird? There are many reasons for it. Good ones are:
  - the low-level driver often provides the samples as interleaved
  - cache efficiency
  - SIMD efficiency
  - programmer's choice
- Quiz:
  - What is the address of A3?
  - Given numChannels and numFrames, how do you access frame f of channel ch?
    (A: ch=0, B: ch=1, C: ch=2)
    buffer[f*numChannels + ch]

Multichannel buffers

- A non-interleaved buffer containing 4 samples from 3 channels A, B, C, will look like:

float buffer[12] = {A0, A1, A2, A3, B0, B1, B2, B3, C0, C1, C2, C3};

- Better? At least for the following reasons:
  - easier to split channels out of the buffer
  - perhaps more intuitive
- Quiz:
  - What is the address of A3?
  - Given numChannels and numFrames, how do you access frame f of channel ch? (A: ch=0, B: ch=1, C: ch=2)
    buffer[ch*numFrames + f] // non-interleaved

Multichannel buffers

- Sometimes, non-interleaved buffers are stored as arrays of float*, e.g.:

  float A[4] = {A0, A1, A2, A3};
  float B[4] = {B0, B1, B2, B3};
  float C[4] = {C0, C1, C2, C3};

  float* buffer[3] = {A, B, C};
  float** ptr = buffer;
- Quiz:
  - What is the address of C3?
  - What is the size of buffer?
  - Given numChannels and numFrames, how do you access frame f of channel ch?

Multichannel buffers quiz

- What is the address of C3?
- Answer: &C[3] = &(buffer[2][3]) = *(&buffer[2])+3 = *(ptr+2)+3
- What is the size of buffer?
- Answer: Contains 3 pointers to float arrays, therefore 3
  in memory: 3*sizeof(float*)
- Given numChannels and numFrames, how do you access frame f of channel ch?
  A == buffer[0]
  A0 == A[0]
  A0 == buffer[0][0]
  buffer[ch][f]

Exercise

- Write a function that converts an interleaved buffer into a non-interleaved buffer.
  void deInterleave(float* input, float* output, size_t numChannels, size_t numFrames)

- Write a function that converts a non-interleaved buffer into an interleaved buffer.
  void interleave(float* input, float* output, size_t numChannels, size_t numFrames)

- Extra: call functions with different container datatypes (C-array, std::vector, std::array, etc.)

Approaching a coding task

1. Define interface of code (public methods of class, function signature)
   - Already given today
2. Write usage example/tests
3. Implement interface (adding additional private methods, members or helper functions)